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LEAK TEST OF X-20A PRESSURIZED COMPARTMENTS

The Boeing Company

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Flight Dynamics Laboratory
Research and Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

# FOREWORD

This report was prepared by The Boeing Company under USAF contract Number AF 33(615)-1792. The contract was initiated under Project Number 620A, Task Number 620A. The work was administered under the direction of the AFFDL Project Engineer: F. E. Barnett.

This report covers work conducted from January 1964 to November 1964.

At the time of the X-20A contract termination in December 1963, the Pilot's Compartment Structural Assembly and the Equipment Compartment Structural Assembly scheduled for use in the Environmental Test Model were in the final phases of structural assembly. Under the auspices of the Air Force Flight Dynamics Laboratory, Research and Technology Division, Air Force Systems Command, a decision was made to complete the structural fabrication of each compartment and to conduct appropriate leak tests.

The compartment configuration and test results are described in this report for use in future flight hardware design programs.

This report is not releasable to OTS because X-20A information is considered sensitive. Future release of this report to OTS will depend on relaxation of dissemination restrictions on X-20A data by the United States Air Force or the United States Department of Defense.

Publication of this technical documentary report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

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# ABSTRACT


To verify the design and fabrication techniques utilized during the technical development of pressurized compartments for the X-20A vehicle, structural fabrication and leak tests were completed on a pilot's compartment and an equipment compartment.

The compartments in production for the Environmental Test Model were completed to a test configuration which eliminated all non-structural items such as equipment support structure, foot well, ducts, internal equipment, wiring, and plumbing. Compartment penetrations were made in accordance with the designed flight configuration except that a reduced number of electrical penetrations were made.

The inflatable seal system functional test of the pilot's hatch, the pilot's compartment equipment access door, and the equipment compartment access door verified that these systems would retain sufficient pressure to provide a satisfactory compartment seal.

A proof pressure test of each compartment demonstrated the integrity of the structure.

The actual leak rate of the pilot's compartment was found to be .025 pounds of air per minute, well within the design goal of 0.168 pounds of air per minute, and the actual leak rate of the equipment compartment was found to be .021 pounds of air per minute, also well within the design goal of 0.100 pounds of air per minute.

These tests demonstrated that the design and fabrication techniques used would produce a compartment capable of performing the X-20A vehicle mission.

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## INTRODUCTION

The X-20A compartments were designed to contain pressures during the anticipated flight regimes with limited leakage of pressurizing gas, limited deflections, and a minimum of structural weight. The pilot's compartment was to be pressurized to 7.35 psia at altitudes above 18,000 feet with the pilot's pressure suit exhaust gas and the equipment compartment was to be pressurized to 10.2 psia at altitudes above 10,250 feet with a fixed flow of gaseous nitrogen. The maximum pressure differential during ascent to and descent from the pressurizing altitude was to be limited to 1.5 psi in each compartment.

During the development phases of the X-20A program various seal configurations and materials were investigated, studied, and tested. The results of these efforts are reflected in the vehicle design released for production. A development program was also conducted by manufacturing personnel to verify the machining and welding capabilities necessary to fabricate a compartment.

At the time of X-20A contract termination, neither a pilot's compartment nor an equipment compartment had been structurally completed, sealed, and pressure tested. This program was instigated to complete the compartments structurally, install flight configuration seals, and perform pressurized tests to verify the adequacy of techniques selected from the development programs.

The compartment configuration tested deviated from a flight configuration compartment in several ways. First, all non-structural assemblies and details not already installed were eliminated. This included ducts, foot wells, equipment support brackets, plumbing, wiring, and equipment. Second, only a portion of the electrical penetrations were made in each compartment due to a shortage of completed electrical receptacles. This was of no significance in the total leak rate since the receptacle sealing proved in development tests and in this program to be leak free. All other penetrations conformed to the flight vehicle design in quantity and configuration. Third, aluminum alloy plate was substituted for the window glass in the pilot's compartment.

## SECTION 1

## CONFIGURATION

### A. INTRODUCTION

The X-20A Pilot's Compartment and Equipment Compartment are minimum weight, pressurized assemblies suspended within the glider primary structure by a determinate system of fittings designed to prevent the compartments from carrying primary loads and to isolate the compartments from primary structure thermal deformation.

### B. PILOT'S COMPARTMENT

The pilot's compartment, containing the flight station and guidance equipment, is pressurized to 7.35 psia at altitudes above 18,000 feet. The compartment atmosphere is provided by exhausting the pilot's pressure suit gas flow directly into the compartment. The compartment pressure is controlled by regulating the flow of compartment atmosphere escaping through a pressure regulator. The safety valve and pressure regulator control the pressure differential to 1.5 psig maximum during ascent to and descent from 18,000 feet altitude.

The compartment, Figures 1 through 4, is a conventional semi monocoque structure with frame supported skin panels, an equipment access door, hatch, and windows. The skin panels, machined from 2219 aluminum alloy plate, are joined together by automatic welding to eliminate leakage. The frames, machined from 7075 aluminum alloy plate, are attached to the skin panel weldment by interference fit mechanical fasteners. The frames, continuous around the inside of the compartment except at the access openings, carry the structural loads so that only local internal pressure loads are carried across the skin panel weld joints.

The pilot's hatch, Figure 5, machined from rolled 2219 aluminum alloy plate, is stiffened by sheet metal frames. Spherical collars and explosive bolts transmit only shear and tension loads to the compartment structure.

The equipment access door is machined from flat 2219 aluminum alloy plate and is then rolled to its cylindrical shape. Pressure loads, as hoop tension, are transferred to the compartment by pin hinges. End bulkheads, welded to the door skin, contain shear pins for distributing loads to the compartment frames.

The soda-lime windows are retained in skin panel openings between stiffeners and frames by bolted retainer plates, Figure 6.

Pressure wall penetrations are reduced to a minimum by allowing only the bolts attaching the three support fittings and the pilot's hatch to pass through the skin panels. All other fasteners common to the panels are contained within blind holes or are through the stiffeners machined into the inner surface.

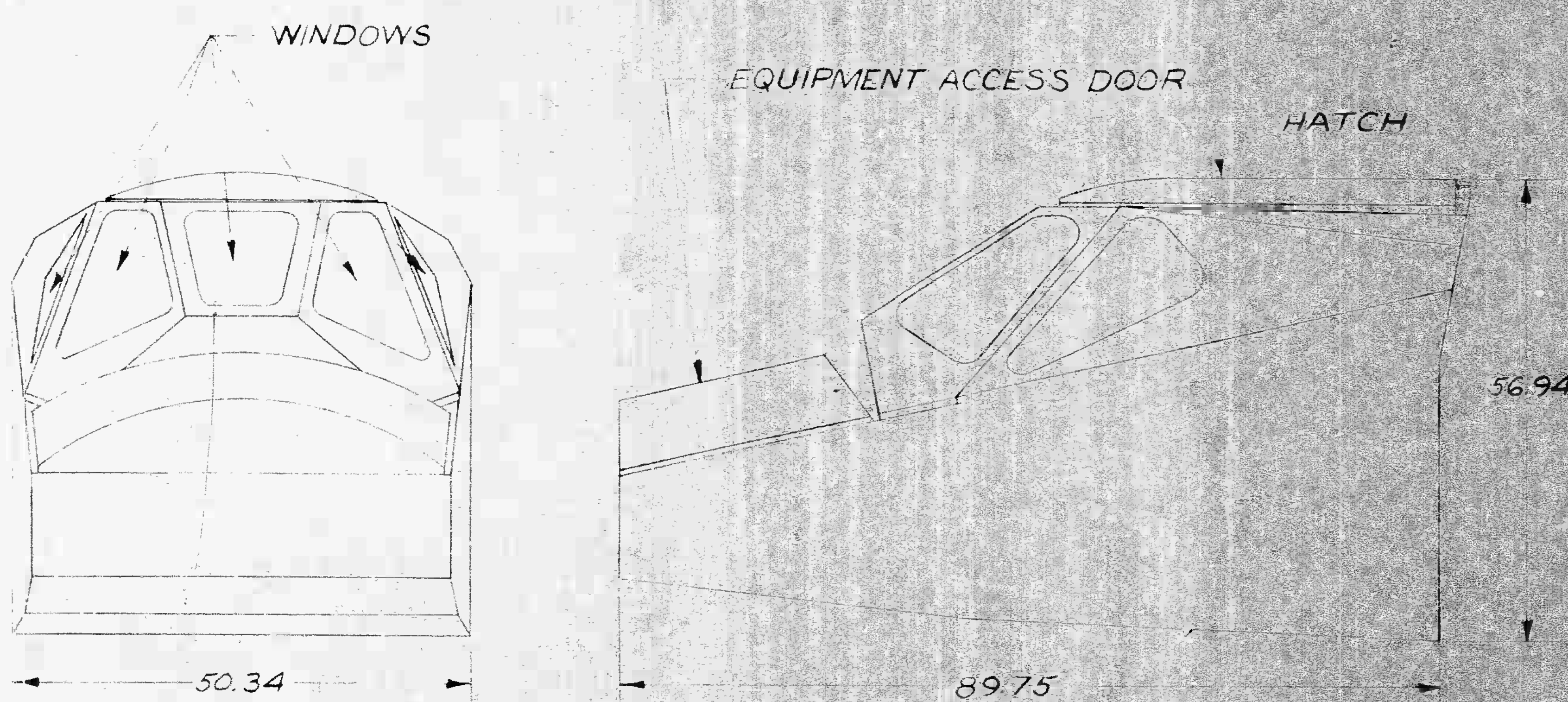


FIGURE 1. PILOT'S COMPARTMENT ENVELOPE

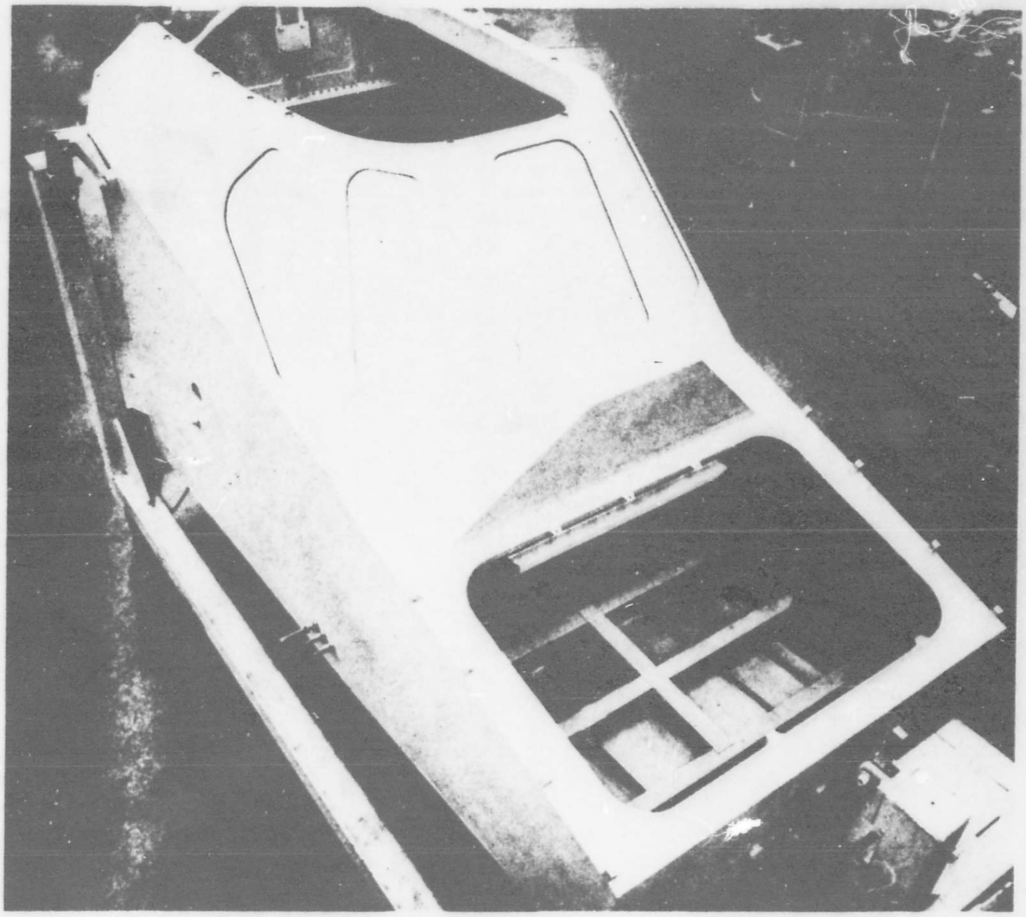

FIGURE 2 PILOT'S COMPARTMENT, HATCH AND ACCESS DOOR REMOVED

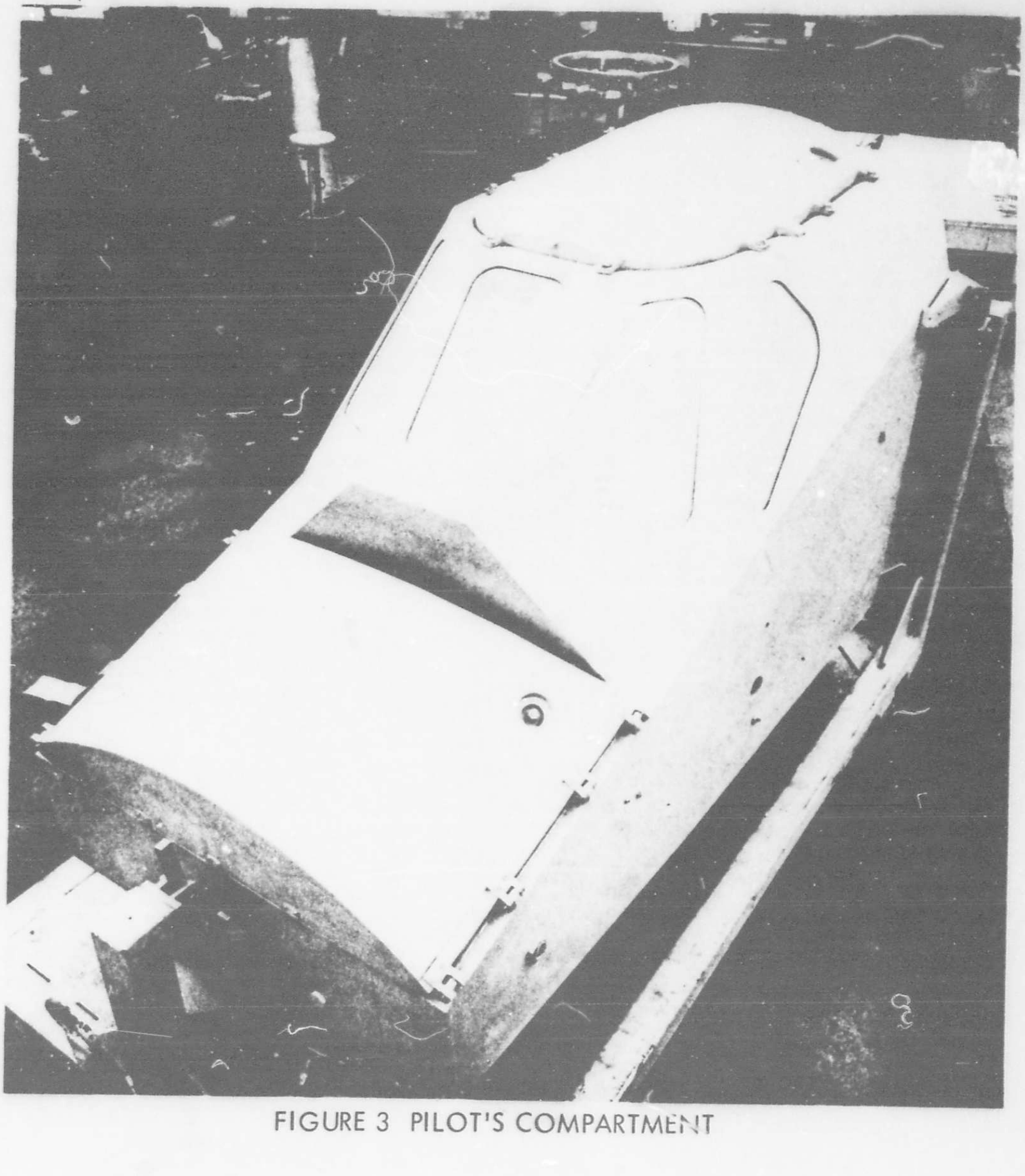

FIGURE 3 PILOT'S COMPARTMENT

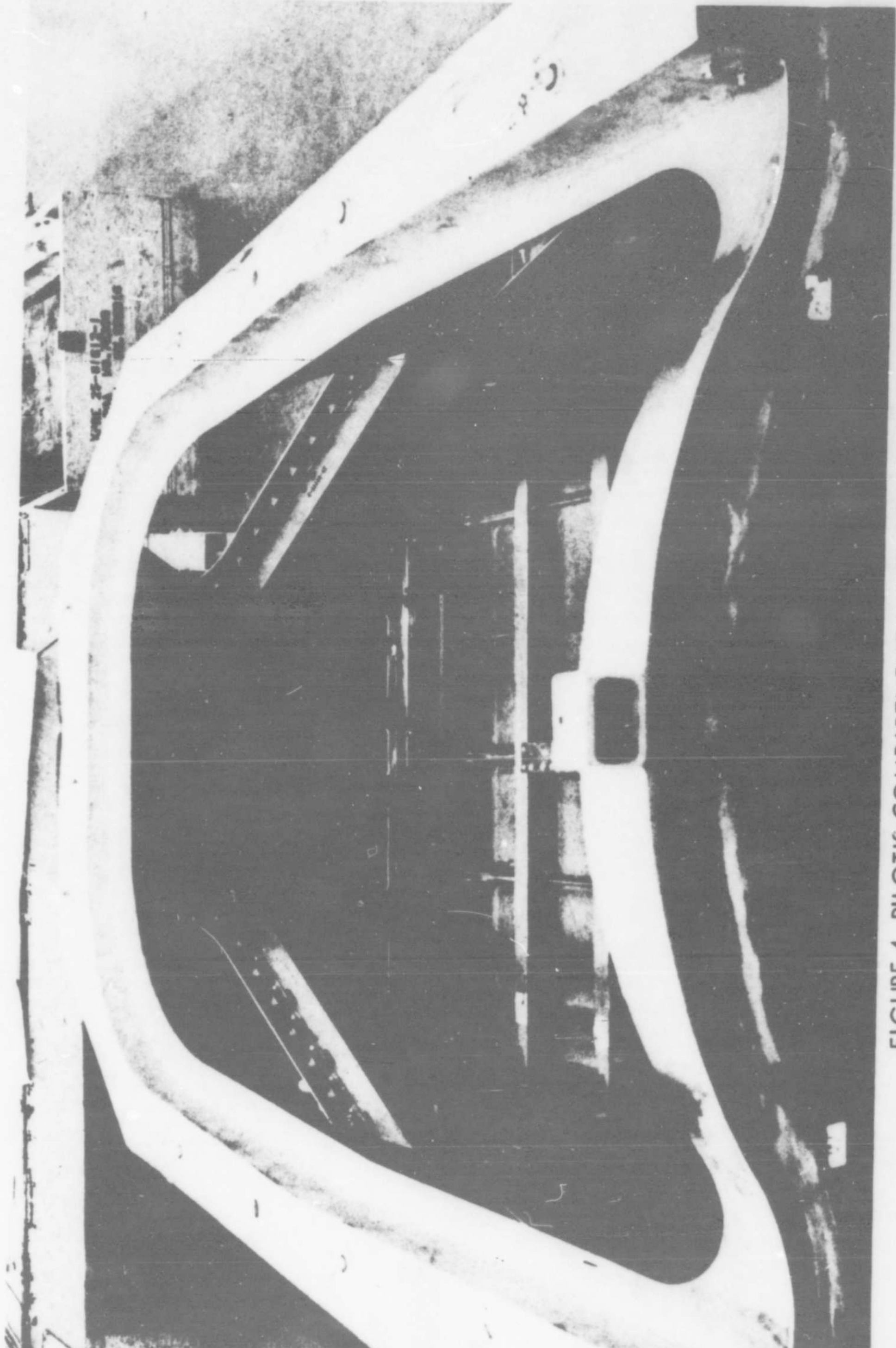

FIGURE 4 PILOT'S COMPARTMENT INNER STRUCTURE

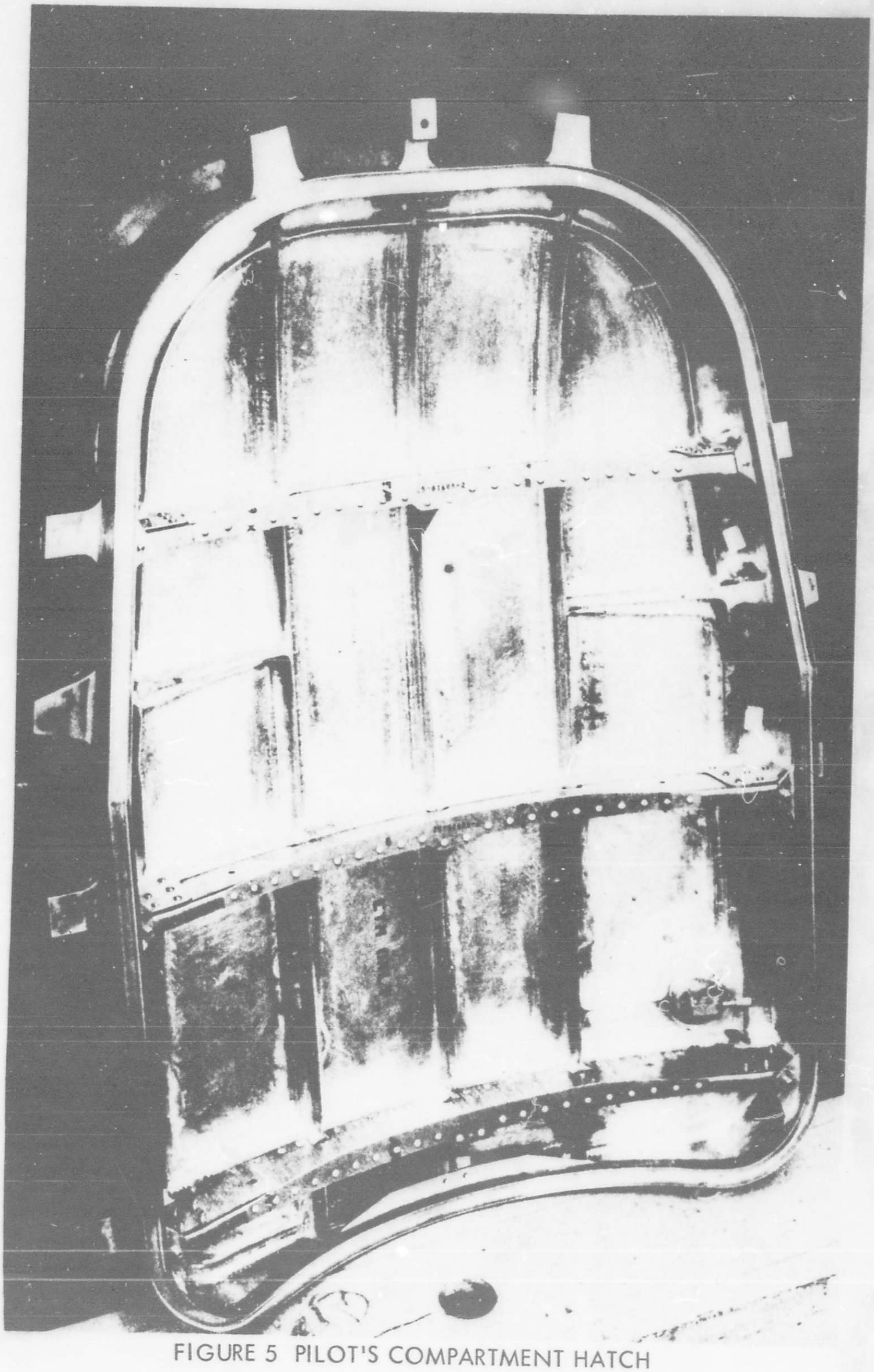

FIGURE 5 PILOT'S COMPARTMENT HATCH

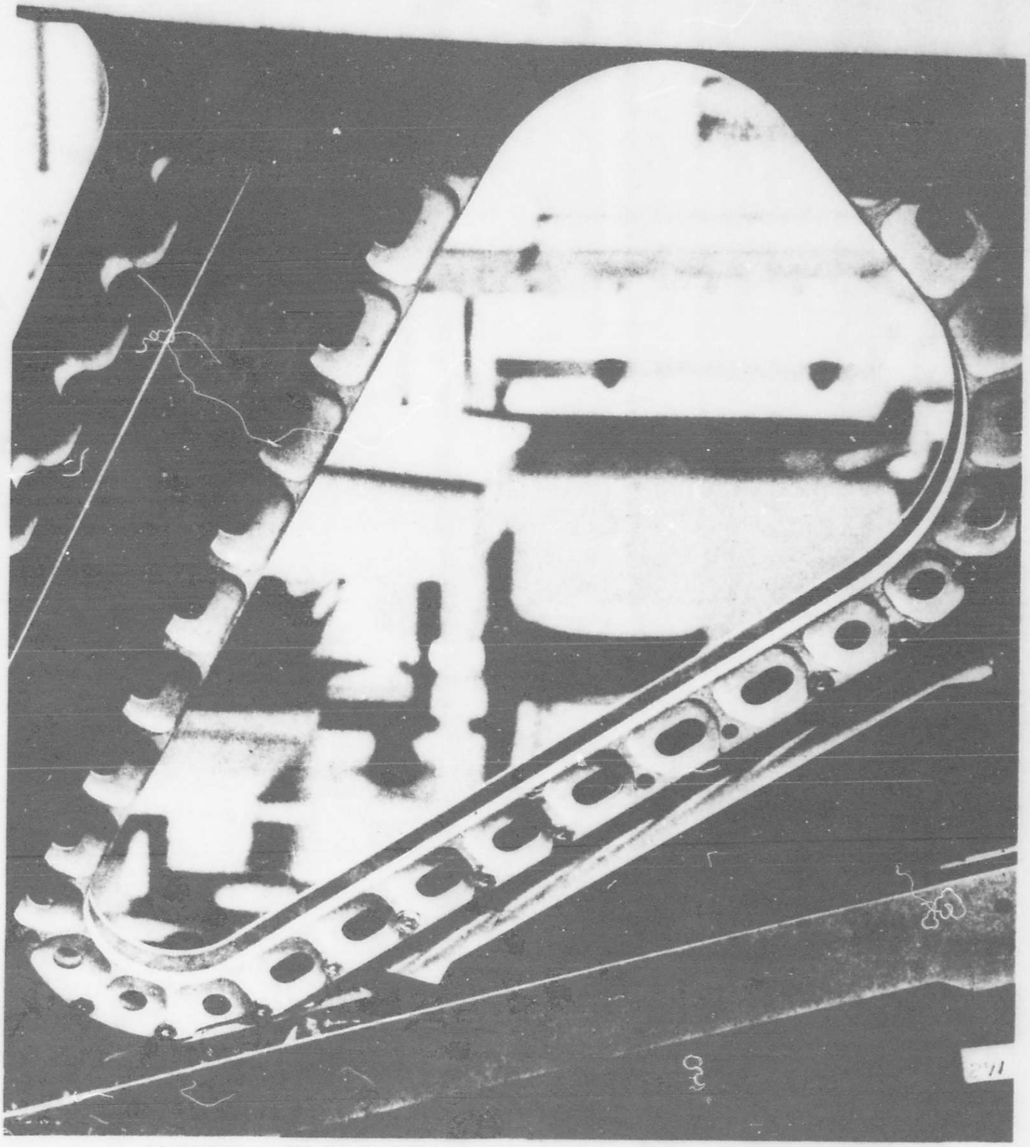

FIGURE 6 PILOT'S COMPARTMENT WINDOW STRUCTURE

## C. EQUIPMENT COMPARTMENT

The equipment compartment, containing electrical and electronic equipment, is pressurized to 10.2 psia at altitudes above 10,250 feet. The compartment atmosphere is provided by a constant inflow of gaseous nitrogen for equipment cooling. The compartment pressure is controlled by regulating the flow of nitrogen escaping through a pressure regulator. A safety valve and the pressure regulator control the pressure differential to 1.5 psig maximum during ascent to and descent from 10,250 feet altitude.

The compartment, Figures 7 through 10, is a conventional semi monocoque structure with frame supported skin panels and an access door. The side and floor skin panels extend aft of the rear pressure bulkhead to form an unpressurized compartment. The skin panels, machined from 2219 aluminum alloy plate, are joined together by automatic welding to eliminate leakage. The frames, machined from 7075 aluminum alloy plate, are attached to the skin panel weldment by interference fit mechanical fasteners. The frames, continuous around the inside of the compartment except at the access door, carry the structural loads so that only local internal pressure loads are carried across the skin panel weld joints.

The access door is machined from flat 2219 aluminum alloy plate and is then rolled to its cylindrical shape. Pressure loads, as hoop tension, are transferred to the compartment by pin hinges. End bulkheads, welded to the door skin, contain shear pins for distributing loads to the compartment frames.

Pressure wall penetrations are reduced to a minimum by allowing only the bolts attaching the two forward support fittings and the electrical umbilical receptacle to pass through the skin panels. All other fasteners common to the panels are contained within blind holes or are through the stiffeners machined into the inner surface. Electric cables are carried to bulkhead receptacles in the pilot's compartment by an intercompartment bellows. This tunnel is sealed from the pilot's compartment atmosphere and is open to the equipment compartment atmosphere.

## D. TEST ARTICLE CONFIGURATION

The compartments tested are structurally identical to the X-20A Pilot's Compartment and Equipment Compartment. Unique part numbers were used to identify the test configuration compartments due to the elimination of the non-structural items such as equipment support bracketry, foot well, ducts, wiring, plumbing, etc., and the substitution of aluminum plate for the window glass.

The seal gap, Figure 10, for the inflatable seal in the pilot's hatch and the equipment compartment access door did not conform with the design requirements due to manufacturing coordination problems encountered on the first X-20 production parts. The seal gap was oversize so the seal plane was built up to a more desirable condition by bonding on a tapered shim. This shim with a filler material fairing at the end may be see in Figure 16. The

pilot's hatch seal gap was reduced in two stages. First, the gap along the front and sides was made .25, the design target. The gap at the aft end was made .50. After a preliminary leak test the gap at the aft end was reduced to .25 for the final leak testing. The equipment compartment seal was reduced to approximately the design target of .29. During testing additional gap reduction was employed to determine the seal capabilities under various gap conditions.

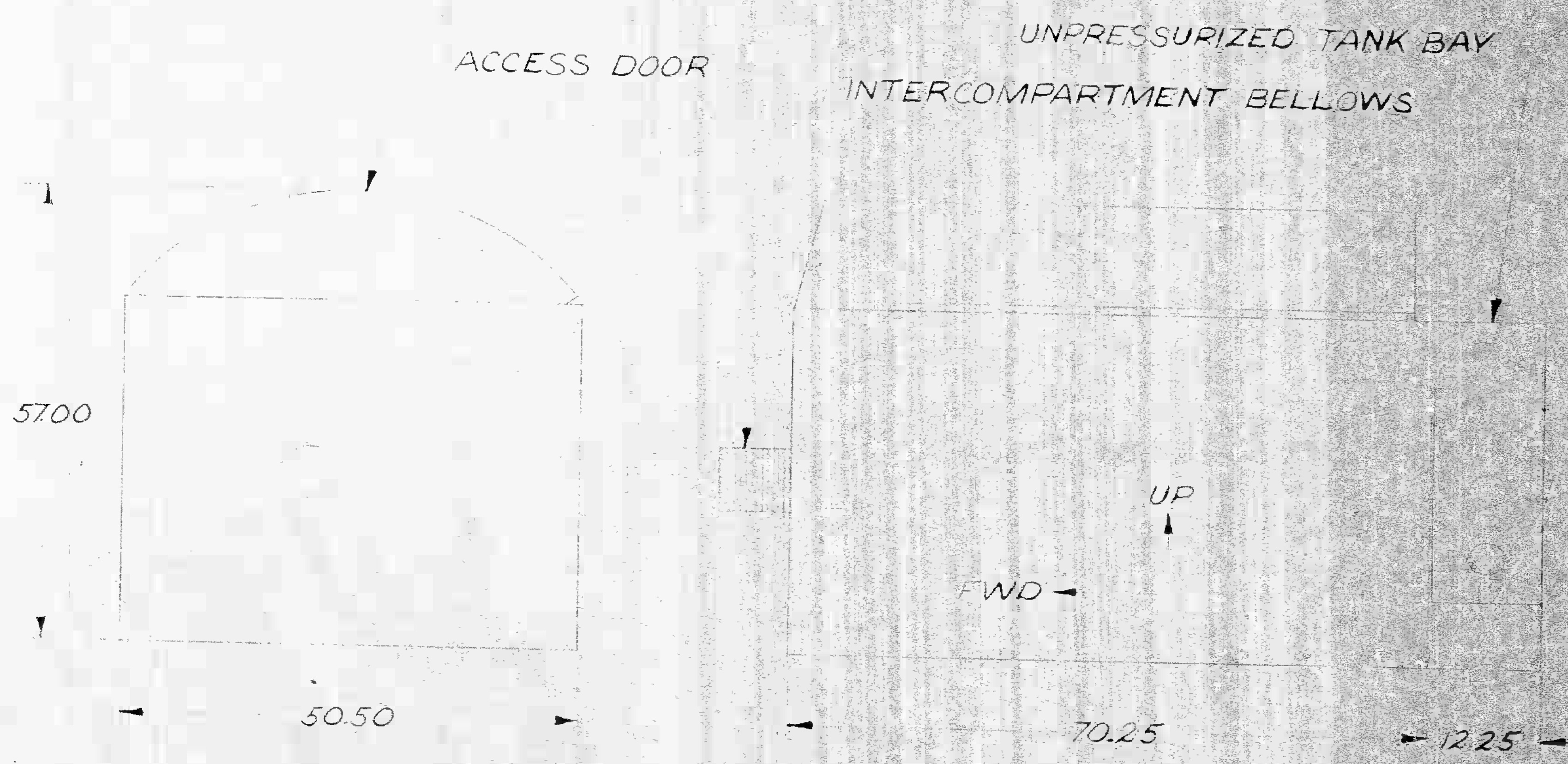


FIGURE 7. EQUIPMENT COMPARTMENT ENVELOPE

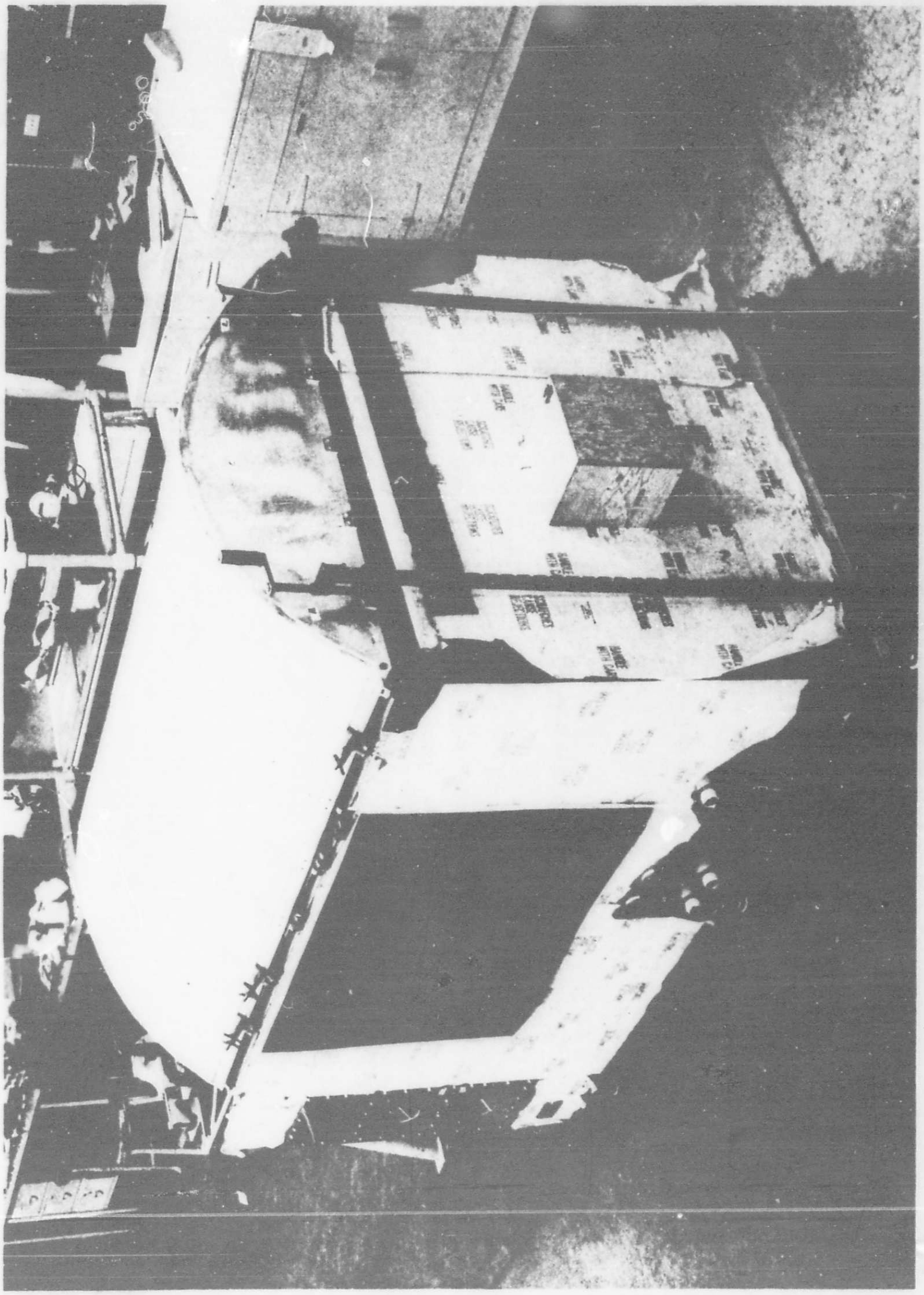

FIGURE 8 EQUIPMENT COMPARTMENT DURING ACCESS DOOR INSTALLATION

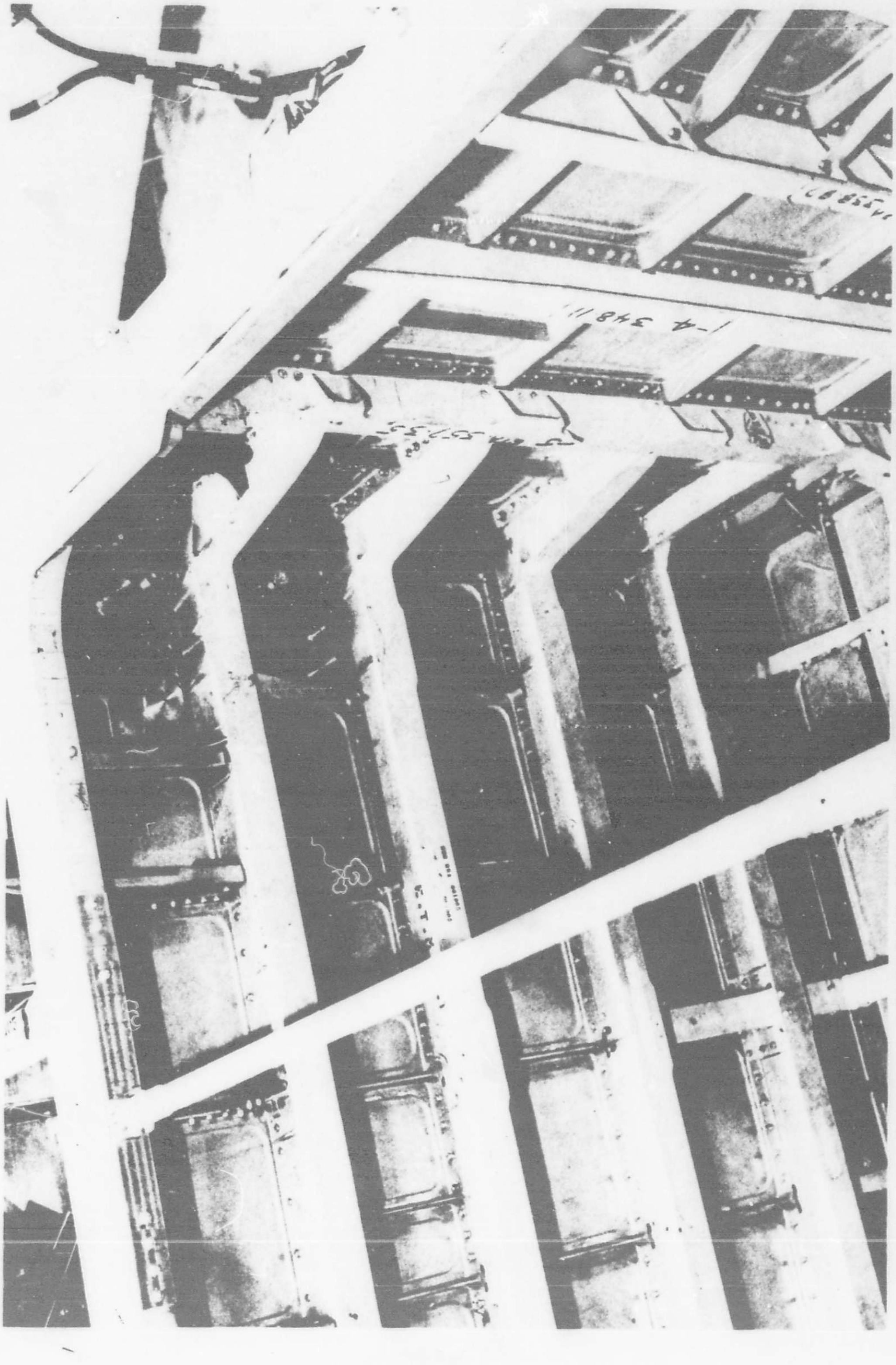

FIGURE 9 EQUIPMENT COMPARTMENT INNER STRUCTURE

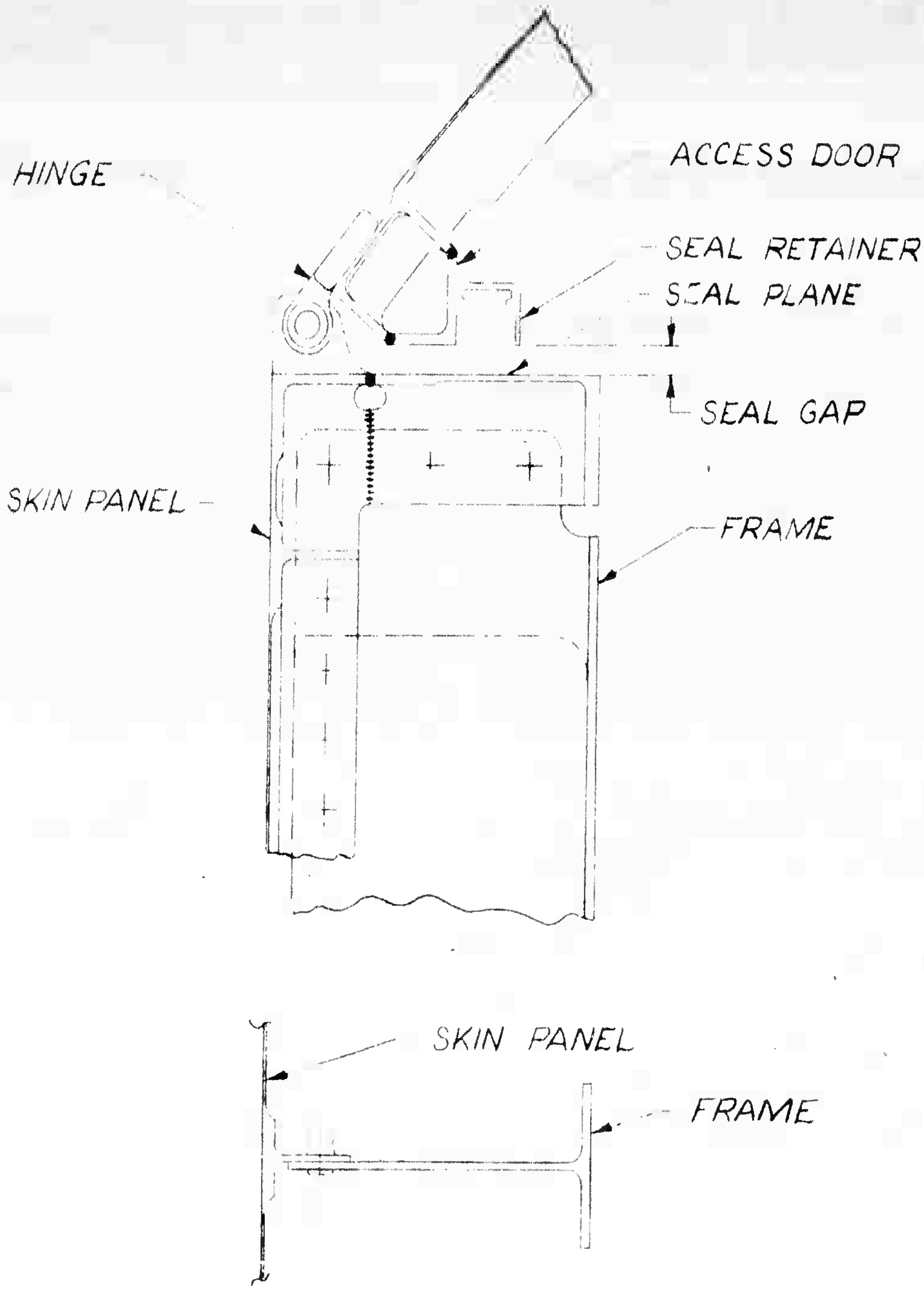


FIGURE 10. EQUIPMENT COMPARTMENT STRUCTURE

## SECTION 2

## SEALING TECHNIQUES

### A. INTRODUCTION

The compartment openings and penetrations are sealed to limit the leakage to insure a flow of compartment pressurizing gases through the pressure regulator. A variety of seals, as shown in Table 1, are used.

### B. INFLATABLE SEALS

The pilot's hatch, pilot's compartment equipment access door, and the equipment compartment access door are sealed with a fabric covered, inflated, rubber compound seal. The seal, installed in a retainer on the applicable cover, would have been inflated to 15 psig at vehicle launch for an equivalent pressure of 30 psia in space. Due to the short duration of the X-20A mission, provisions for maintaining seal pressure were not required and the seal was closed by a valve. Figure 11 provides details of the seal and seal installation.

### C. WINDOW SEALS

The pilot's compartment windows are sealed by a molded, "U" shaped, silicone rubber seal. The two legs of the seal are compressed a total of 0.10 by the window retainer plate. The leg of the seal between the window and the retainer plate does not function as a seal but as a window support. Figure 12 provides details of the seal and seal installation.

### D. GASKET SEALS

All electrical receptacles, intercompartment bellows, pilot's hatch bolts, and other miscellaneous penetrations are sealed with standard molded rubber compound seals in metal retainers. A typical gasket seal and gasket seal installation are shown in Figure 13.

The electrical system for each X-20A mission was different but all compartments were to be capable of being used for any mission. For this reason, many electrical penetrations are filled with a solid dummy receptacle having sealing surfaces identical to those of an electrical receptacle. The test configuration compartment has a reduced number of electrical penetrations since the required quantity of receptacles and dummy receptacles were not available at the time of the X-20A program termination.

### E. "O" RING SEALS

The pressure regulators, safety valves, and support fitting attach bolts are sealed with standard "O" ring seals as are the valves in the inflatable seal system.

TABLE 1

LENGTH OF SEAL IN COMPARTMENTS

| TYPE OF SEAL | PILOT'S COMPARTMENT FLIGHT CONFIGURATION (Inches) | PILOT'S COMPARTMENT TEST CONFIGURATION (Inches) | EQUIPMENT COMPARTMENT FLIGHT CONFIGURATION (Inches) | EQUIPMENT COMPARTMENT TEST CONFIGURATION (Inches) |
|---|---|---|---|---|
| INFLATABLE SEAL | 250 | 250 | 210 | 210 |
| MOLDED WINDOW SEAL | 280 | 280 | - | - |
| GASKET SEAL | 267 | 183 | 277 | 253 |
| "C" RING SEAL | 39 | 39 | 39 | 39 |
| METALLIC SEAL | 15 | 15 | 29 | 29 |

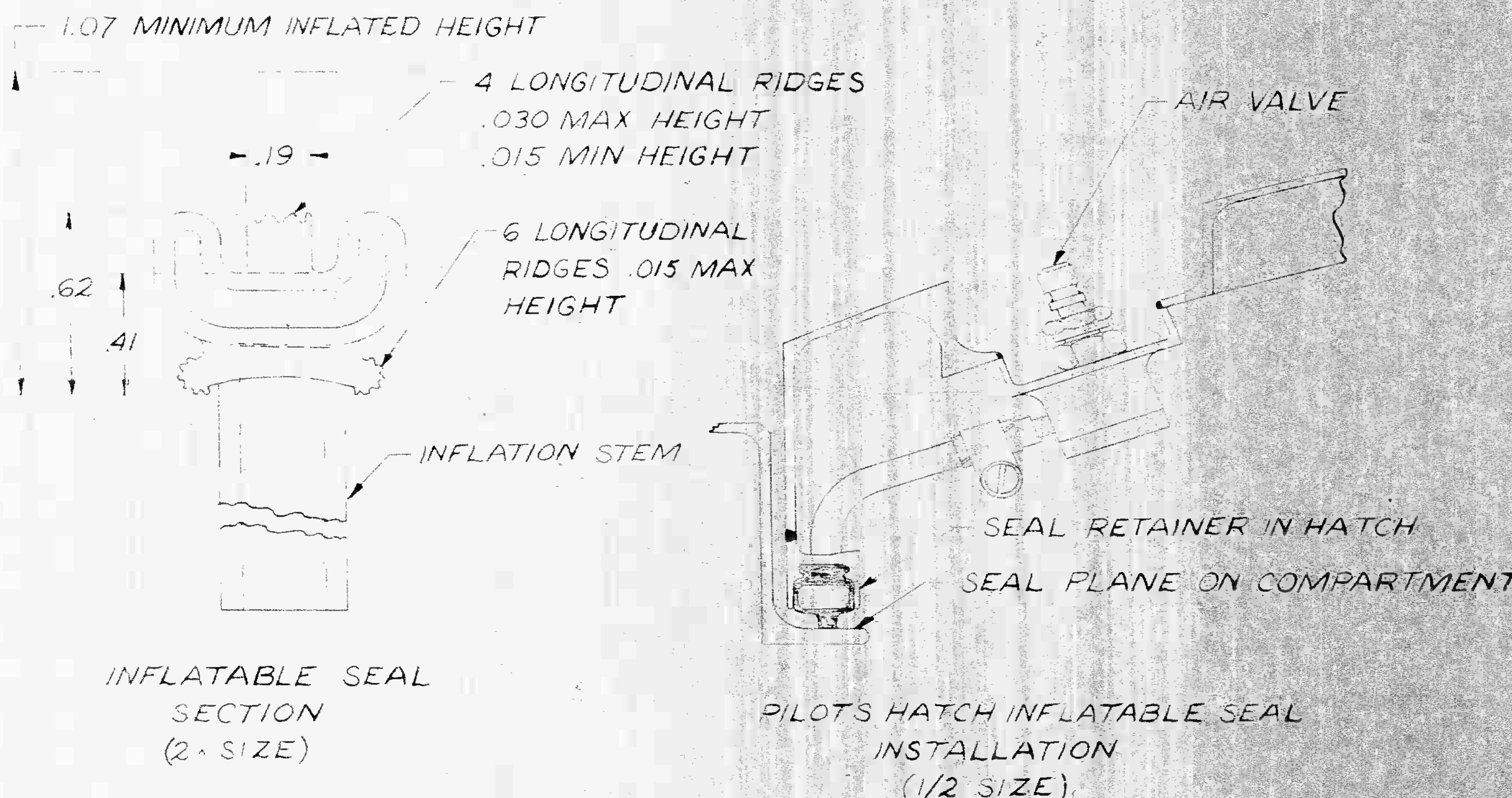


FIGURE 11. INFLATABLE SEAL DETAIL AND INSTALLATION

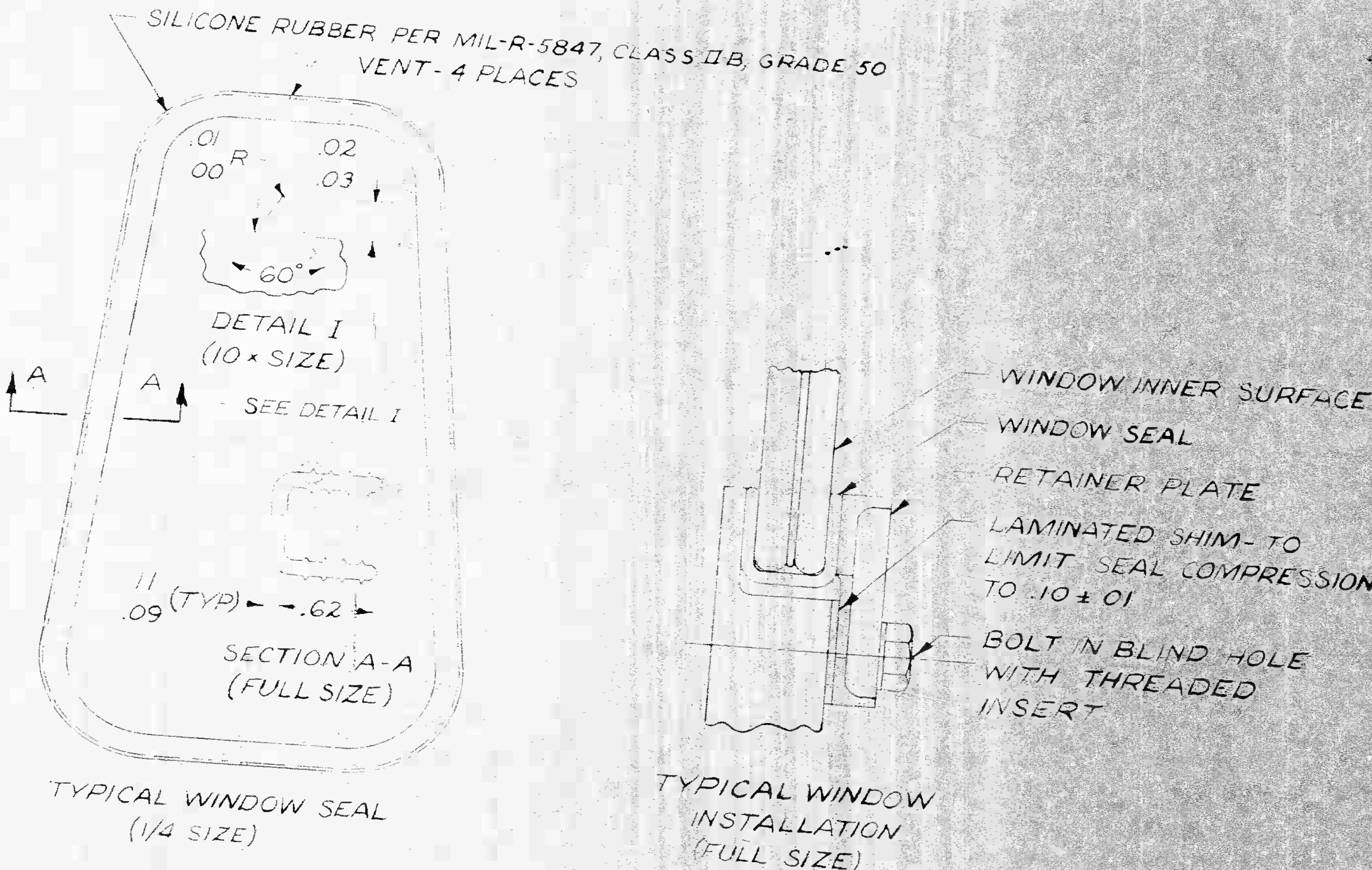


FIGURE 12. WINDOW SEAL DETAIL AND INSTALLATION

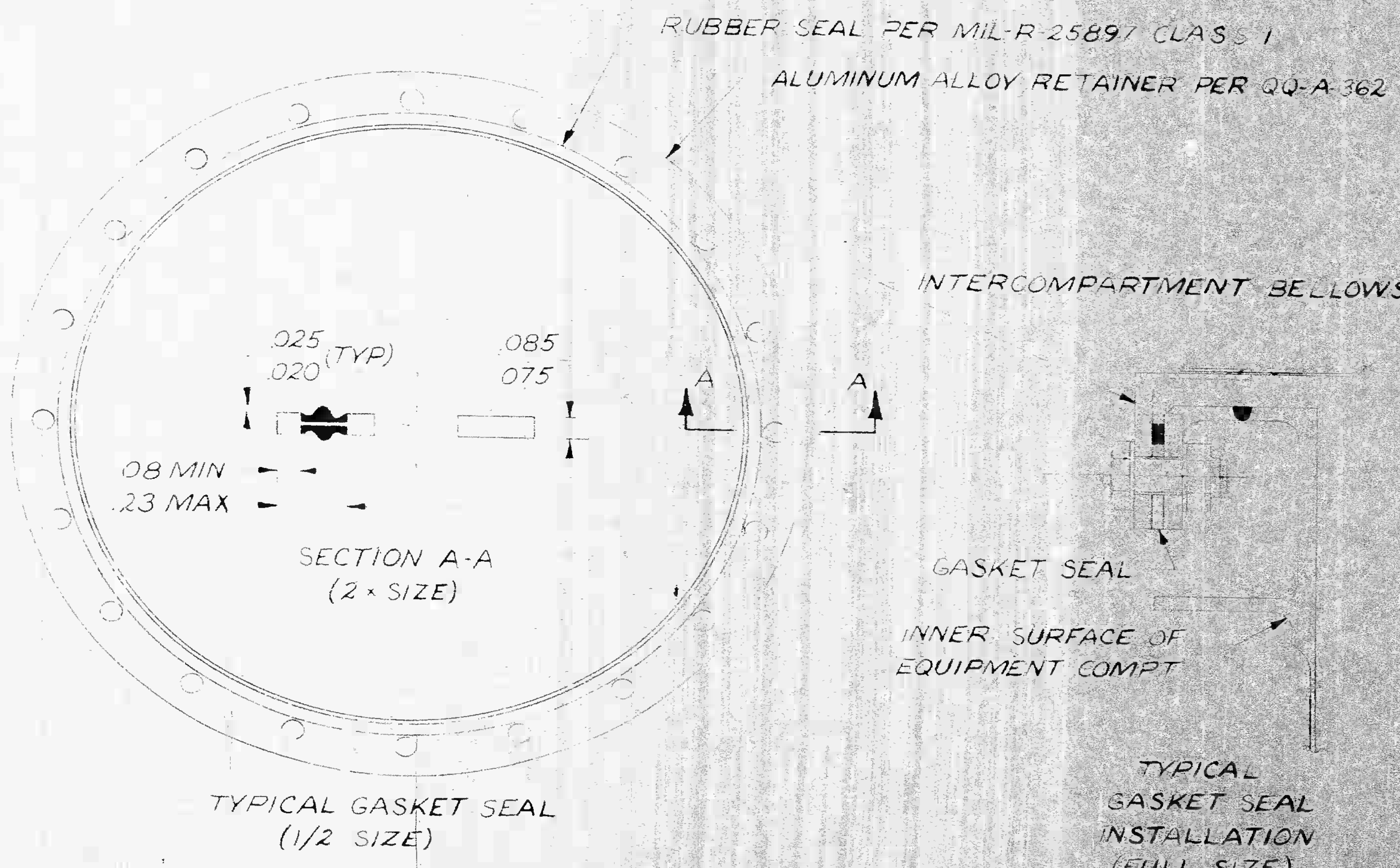


FIGURE 13. GASKET SEAL DETAIL AND INSTALLATION

## F. METALLIC SEALS

The bulkhead unions and connectors used with the plumbing systems employ a metal seal manufactured by NAVAN Products, Incorporated, 1320 E. Imperial Highway, El Sagundo, California. The seal and a typical seal installation are shown in Figure 14.

## G. EFFECTIVENESS OF SEALS

The predicted leakage for the pilot's compartment is 0.025370 pounds of pressurizing gas per minute. The inflatable seals in the hatch and equipment access door represent 96.45% of this total and the molded window seals account for 3.42% of the total leakage.

The predicted leakage for the Equipment Compartment is 0.020583 pounds of pressurizing gas per minute. The inflatable seal in the access door represents 99.98% of this total.



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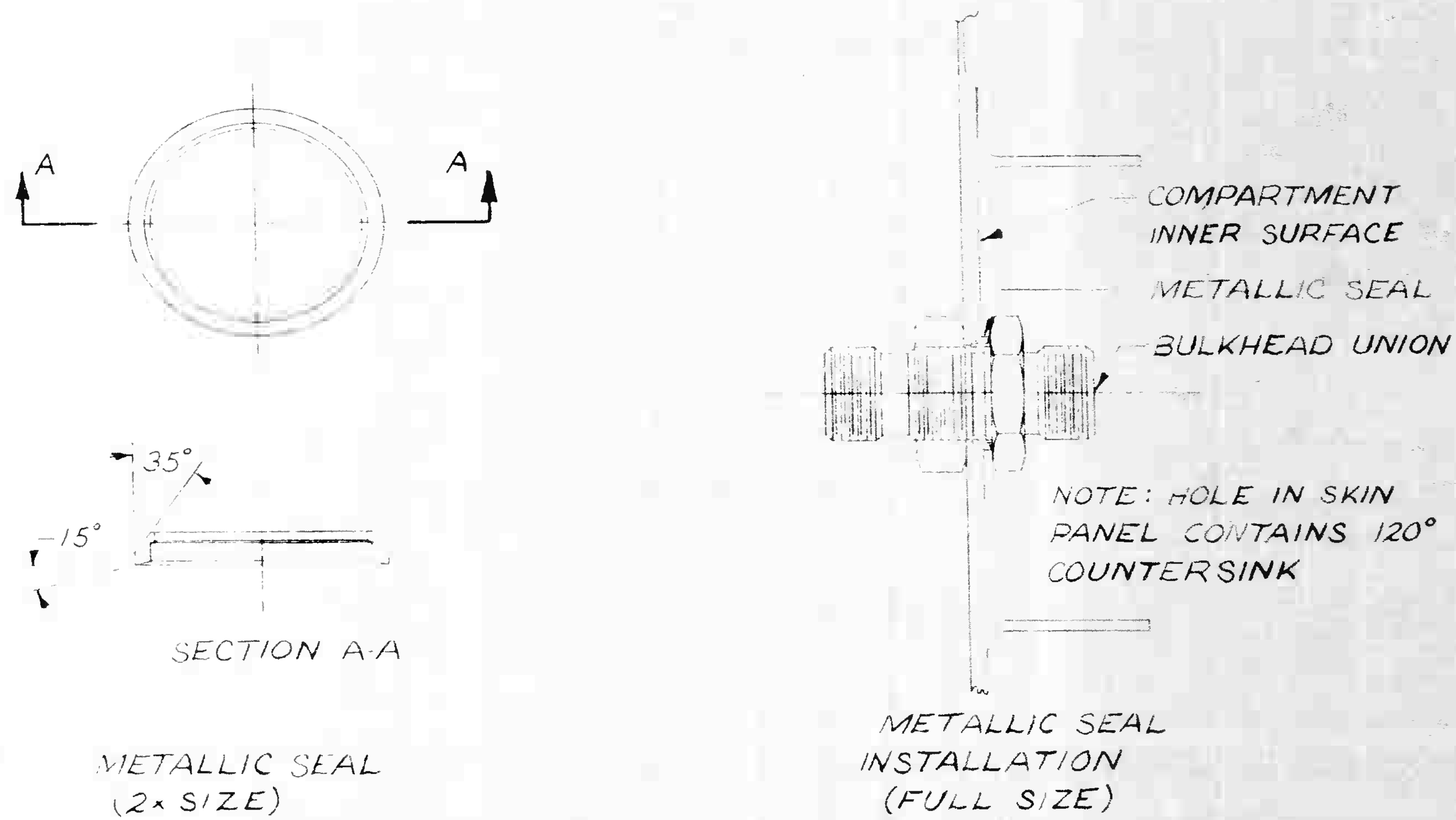


FIGURE 14. METALLIC SEAL DETAIL AND INSTALLATION

SECTION 3

INFLATABLE SEAL FUNCTIONAL TEST

A. PURPOSE

Each inflatable seal system was tested to demonstrate the capability of the system to maintain pressurization during an established time period.

B. TEST ARTICLE

The inflatable seal system functional test was conducted on the completed installation in the applicable hatch or access door prior to the installation of the hatch or door onto the compartment. The inflatable seal was free to expand, except as restricted by the seal retainer.

C. TEST PROCEDURE

Each seal system was pressurized to 30 psig plus or minus 1.0 psig and was then isolated from the pressure source. After 24 hours, the pressure was measured and those systems with a pressure reduction of 5 psig or less were accepted.

D. TEST RESULTS

All inflatable seal systems tested were found to be acceptable although the equipment compartment access lid seal failed on its first test due to metallic particles under the "O" ring sealing the air valve. The actual pressure reduction measurements are as follows:

| | |
|---|---|
| Pilot's Compartment Equipment Access Door | 3.0 psig (original seal)<br>2.8 psig (replacement seal) |
| Pilot's Hatch | 2.8 psig |
| Equipment Compartment Access Door | 1.1 psig |

## SECTION 4

## COMPARTMENT PROOF PRESSURE TEST

A. PURPOSE

Each compartment was pressurized to a pressure equal to 1.2 times the maximum attainable pressure under operating conditions to demonstrate the integrity of the structure.

B. TEST ARTICLE

The proof pressure test was conducted on complete, sealed compartments, as described in Section 1, Paragraph D, except that the pressure regulator and safety valve were replaced by cover plates.

C. TEST PROCEDURE

The Pilot's Compartment was pressurized to 9.6 psig and the Equipment Compartment was pressurized to 12.7 psig and the pressures were maintained for a minimum of 3 minutes.

D. TEST RESULTS

Examination of each compartment after testing found no evidence of deformation, failure, or other irregularity, demonstrating the structural integrity of the compartments.

Measurements of leakage were also made during the proof pressure test and are presented in Section 5.

## SECTION 5

## COMPARTMENT LEAK TEST

### A. INTRODUCTION

Each compartment was pressurized to the operating pressure and the leakage rate was measured to demonstrate the integrity of the seals.

The leak test was conducted on structurally complete, sealed compartments, as described in Section 1, Paragraph D, except that the pressure regulator was inoperative.

The compartment was pressurized with filtered plant air utilizing a pressure regulator for control and a bulkhead connector installed in the compartment for flight use. The air flow required to maintain the compartment pressure was measured and identified as the leakage rate.

Measurements of leakage were made at increments of the operating pressure, with the access door inflatable seal at various pressures, and with various gaps between the inflatable seal retainer and the seal platform to provide additional information on seal performance.

### B. PILOT'S COMPARTMENT LEAK TESTS

The X-20A Pilot's Compartment was permitted a maximum leakage of 0.168 pounds of pressurizing gas per minute during the pressurized portion of the mission. This leakage rate, 80% of the gas inflow, was also the allowable for this test.

The actual Pilot's Compartment leakage rate was found to be .025 pounds of air per minute at a pressure of 7.3 plus or minus .2 psig.

Table 2 is a compilation of the leakage rate measurements taken during the test program. The inflatable seal in the equipment access door leaked over a 2.5 inch span during the proof test. Examination after the test disclosed a small metallic shaving on the seal but the seal plane was clean and smooth. The seal contained two dimensional distortion in this area. During the first leak test, with a .50 maximum gap under the aft end of the hatch, the access door inflatable seal still leaked. The seal was replaced with a spare prior to the second leak test. The spare seal contained similar distortion but exhibited only minor leakage. The distortion in both seals is at the fill tube and is a correctable problem. Similar seals exhibit a minimum of distortion in this area as may be seen in Figure 17.

TABLE 2

PILOT'S COMPARTMENT LEAK RATE MEASUREMENTS

| CONFIGURATION TESTED | COMPARTMENT PRESSURE | | | | | | |
|---|---|---|---|---|---|---|---|
| | 4.0 | 5.0 | 6.0 | 7.3 | 8.0 | 9.0 | 9.6 |
| PROOF PRESSURE | .014 | .018 | .027 | .035 | .035 | .042 | .049 |
| LEAK, WITH .50 MAXIMUM GAP UNDER AFT END OF HATCH AND DEFECTIVE INFLATABLE SEAL, RUN #1 | .014 | .017 | .025 | .030 | | | |
| LEAK, WITH .50 MAXIMUM GAP UNDER AFT END OF HATCH AND DEFECTIVE INFLATABLE SEAL, RUN #2 | .013 | .022 | .030 | .035 | | | |
| LEAK TEST, REPLACEMENT SEAL AND .25 SEAL GAP, RUN #1 | - | - | .027 | .024 | | | |
| LEAK TEST, REPLACEMENT SEAL AND .25 SEAL GAP, RUN #2 | .012 | .012 | .023 | .025 | | | |
| ALLOWABLE | .124 | .138 | .152 | .168 | .175 | .186 | .192 |

NOTE: Leak Rates Measured in Pounds of Pressurizing Gas per Minute.

## C. EQUIPMENT COMPARTMENT LEAK TESTS

The X-20A Equipment Compartment was permitted a maximum leakage of 0.10 pounds of pressurizing gas per minute during the pressurized protion of the mission. This leakage rate is about 77% of the cooling gas inflow and was the allowable for this test.

The actual Equipment Compartment leakage rate was found to be 0.021 pounds of air per minute at a pressure of 10.2 plus or minus .2 psig.

Table 3 is a compilation of the leakage rate measurements taken during the test program. The compartment exhibited considerable leakage during the proof pressure test but this was found by examination to result from two electrical receptacles that were inadequately torqued and from a defective blind bolt hole that penetrated the pressure wall. Repair of these defects led to the very low leakage rate determined for the subsequent leak test.

Tests were run with the access door inflatable seal pressurized at 15 psig, 20 psig, and 40 psig for comparison with the leak test for which seal pressure was 30 psig. These results, shown graphically in Figure 15, support the selected seal inflation pressure for an X-20A mission.

The designed seal retainer to seal plane gap of .26 minimum and .32 maximum was .300 minimum and .396 maximum with an average of .351 on the completed compartment. Shims were used to reduce this gap by .03 and .06 to investigate the effect of gap on the inflatable seal performance. The leakage rate measured with the .03 shim installed should have been slightly less than the leak test results and the rate measured with the .06 shim installed should have been slightly greater than the leak test results. The test results obtained with the .03 shim are completely erroneous and must result from bonding voids. The test results obtained with the .06 shim pointed out the incorrectness of the tests with the .03 shim and demonstrated that the inflatable seal performance is relatively unaffected by seal gap.

During a series of tests, including leak measurements with the inflatable seal pressurized to 15 and 40 psig, four narrow bands of talc were placed on the seal platform to investigate seal movement. Figures 16 and 17 show the seal platform and the seal after the leak tests. The seal in the corner made contact only with 2 of the four ridges on the foot and moved very slightly outboard while the seal in the straight section made contact with all four ridges and did not move.

## D. CONCLUSIONS

The leak test measurements of the X-20A Pilot's Compartment and Equipment Compartment demonstrated the ability of the seals to limit leakage to approximately 15% of the gas flow into the compartment. Test results illustrated the capability of an inflatable seal to perform with wide variations in seal gap and that an optimum inflation pressure exists for each seal.

TABLE 3

EQUIPMENT COMPARTMENT LEAK RATE MEASUREMENTS

| CONFIGURATION TESTED | COMPARTMENT PRESSURE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 12.7 |
| PROOF PRESSURE TEST | .080 | .015 | .045 | .080 | .078 | .086 | .094 | .089 | .096 |
| LEAK TEST, .351 AVE. SEAL GAP, RUN #1 | .010 | .013 | .011 | .021 | .014 | .021 | | | |
| LEAK TEST, .351 AVE. SEAL GAP, RUN #2 | .010 | .011 | .011 | .021 | .017 | .018 | | | |
| 15 PSIG SEAL PRESSURE, .351 AVE. SEAL GAP, RUN #1 | .065 | .042 | .012 | .041 | .049 | .053 | | | |
| 15 PSIG SEAL PRESSURE, .351 AVE. SEAL GAP, RUN #2 | .012 | .040 | .022 | .046 | .041 | .044 | | | |
| 20 PSIG SEAL PRESSURE, .351 AVE. SEAL GAP | .012 | .025 | .019 | .030 | .021 | .035 | | | |
| 40 PSIG SEAL PRESSURE, .351 AVE. SEAL GAP | - | - | - | .016 | .014 | .020 | | | |
| .030 SHIM, .32 AVE. SEAL GAP, RUN #1 | - | - | .012 | .029 | .033 | .037 | | | |
| .030 SHIM, .32 AVE. SEAL GAP, RUN #2 | - | - | .012 | .020 | .033 | .030 | | | |
| .060 SHIM, .29 AVE. SEAL GAP | .012 | .019 | .019 | .016 | .017 | .024 | | | |
| .060 SHIM, .29 AVE. SEAL GAP, AND 20 PSIG SEAL PRESSURE | .012 | .019 | .022 | .026 | .029 | .030 | | | |
| ALLOWABLE | .071 | .077 | .084 | .090 | .095 | .100 | .105 | .110 | .113 |

NOTE: Leak Rates Measured in Pounds of Pressurizing Gas per Minute.

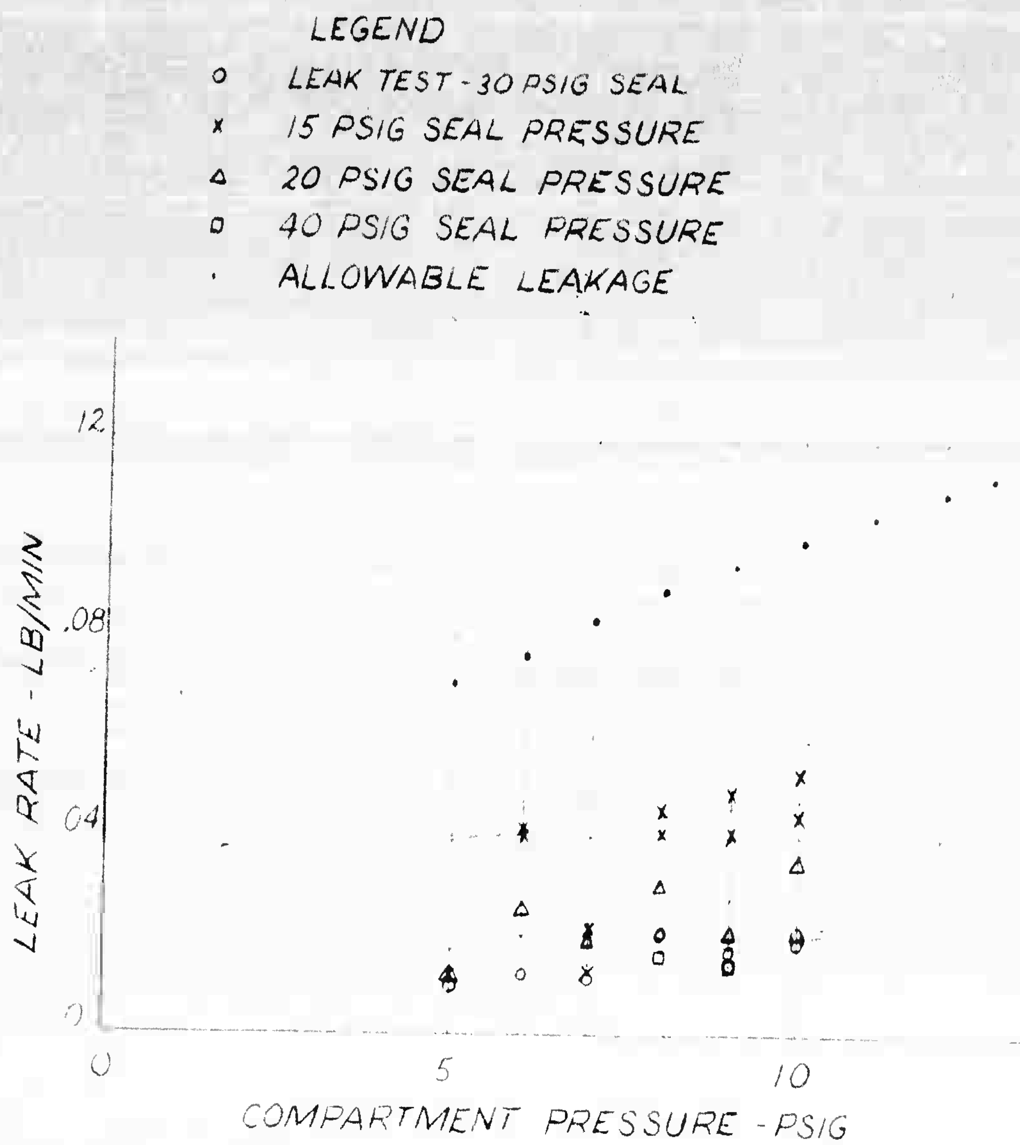


FIGURE 15 LEAK RATE AT VARIOUS INFLATABLE SEAL PRESSURES

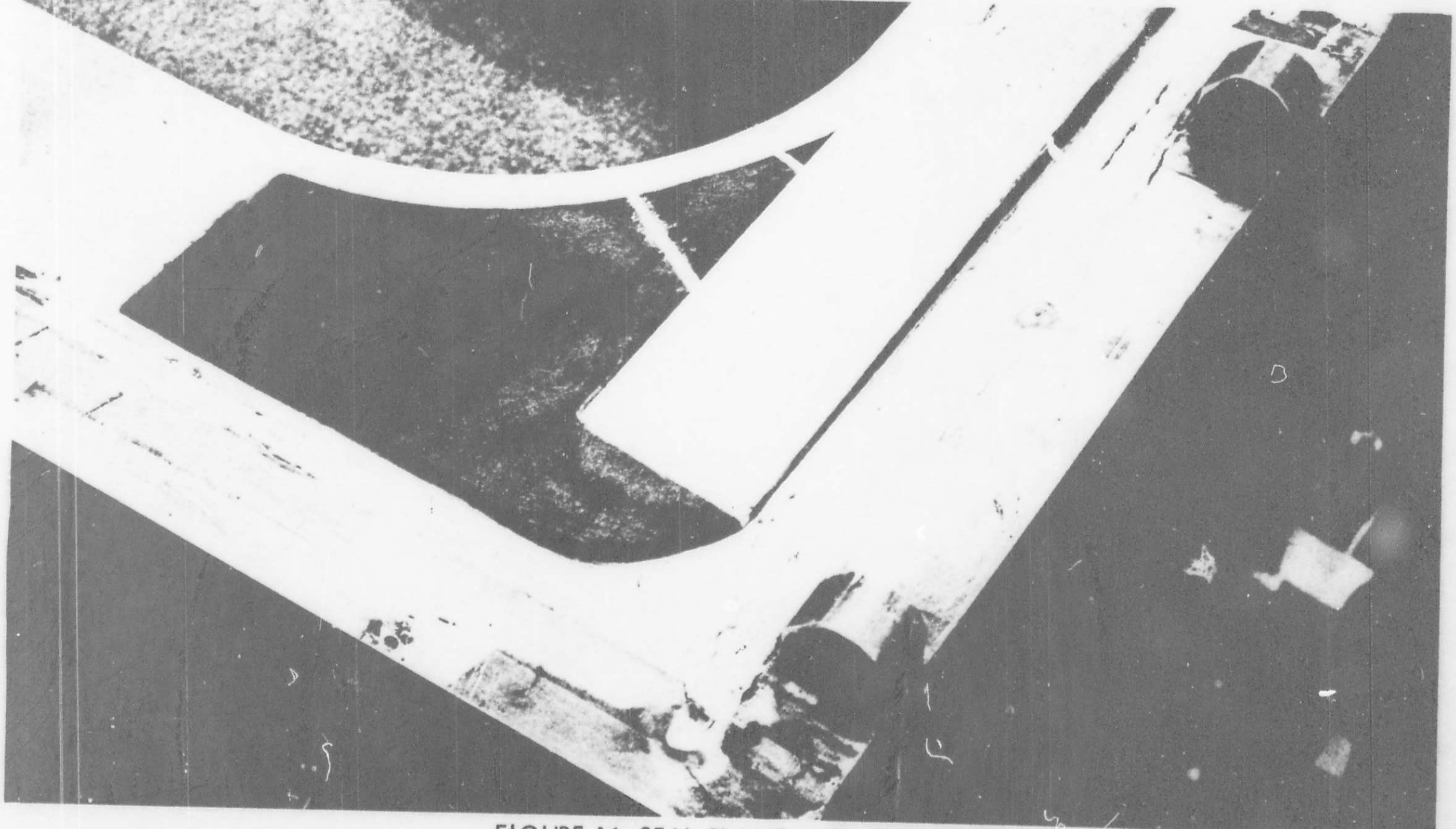

FIGURE 16 SEAL PLANE WITH TALC

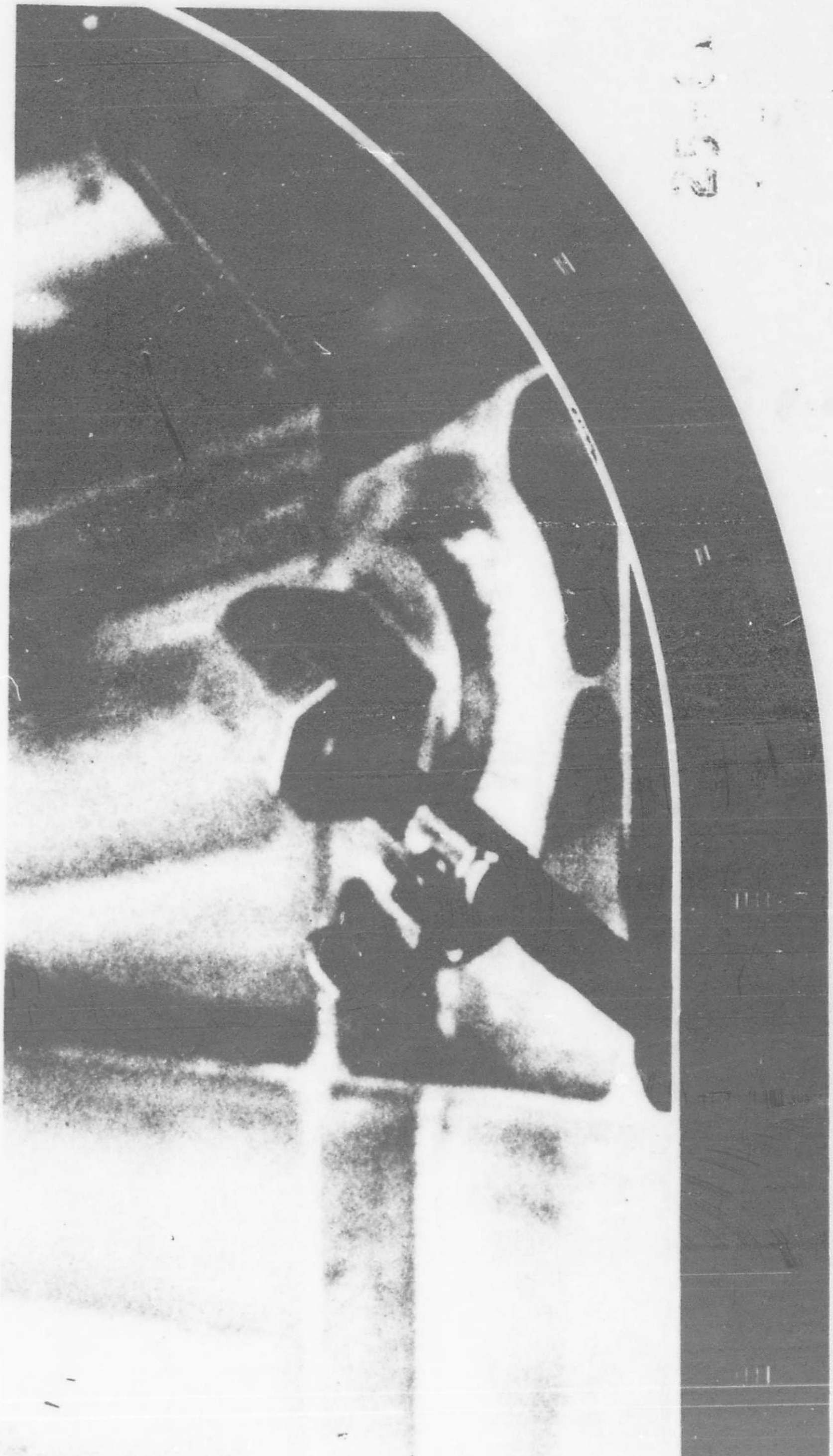

FIGURE 17 INFLATABLE SEAL WITH TALC

## SECTION 6

## DEFLECTION MEASUREMENTS

### A. INTRODUCTION

During the pressurized tests, various deflection and strain measurements were made to compare with the anticipated values and to provide an indication of the deflection absorbed by the inflatable seals.

Measurements were made to determine the increase in seal gap of the hinges, to determine the deflection of various structural members, and to determine the strain in several members. The locations of these measurements are shown in Figures 18 and 19. Figures 20 and 21 show several instrument installations.

### B. RESULTS

Tables 4 and 5 are a summary of the measurements made, and where applicable, the anticipated values.

The measurements of structural deflections and loads are in reasonable agreement with the calculated values. The differences between the calculated and measured values are a result of assumptions, such as not considering a majority of the stiffeners machined into the skin panels, necessary for the manual analysis approach. The use of a computer program would reduce the differences if warranted.

The measurements of the increase in seal gap and deflections in the structure indicate that at the center hinge, the seal gap increased about .05 at the operating pressure. This is a result of taking up bolt clearance in the hinges, rotation of the seal plane with the side frame deflection, and rotation of the seal retainer with the access door deflection. The total deflection was not anticipated to be large and is shown to be well within the bridging ability of the inflatable seal.

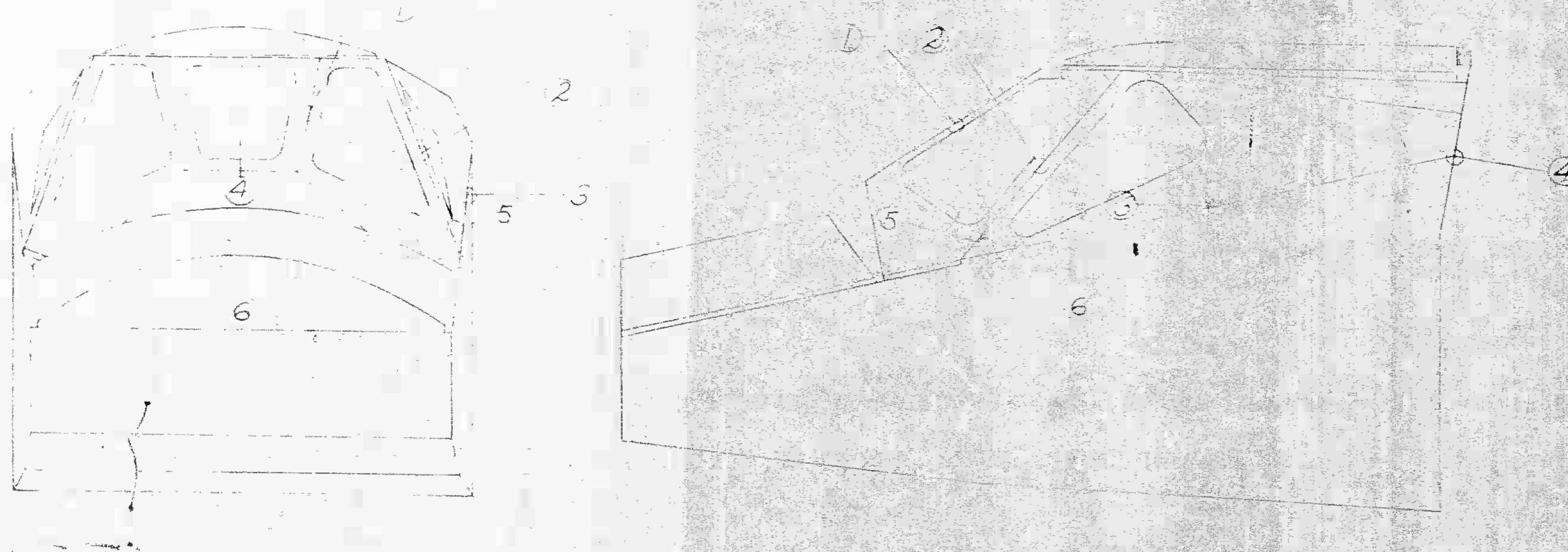


FIGURE 18. LOAD AND DEFLECTION MEASUREMENT LOCATIONS


FIGURE 19. DEFLECTION MEASUREMENT LOCATIONS

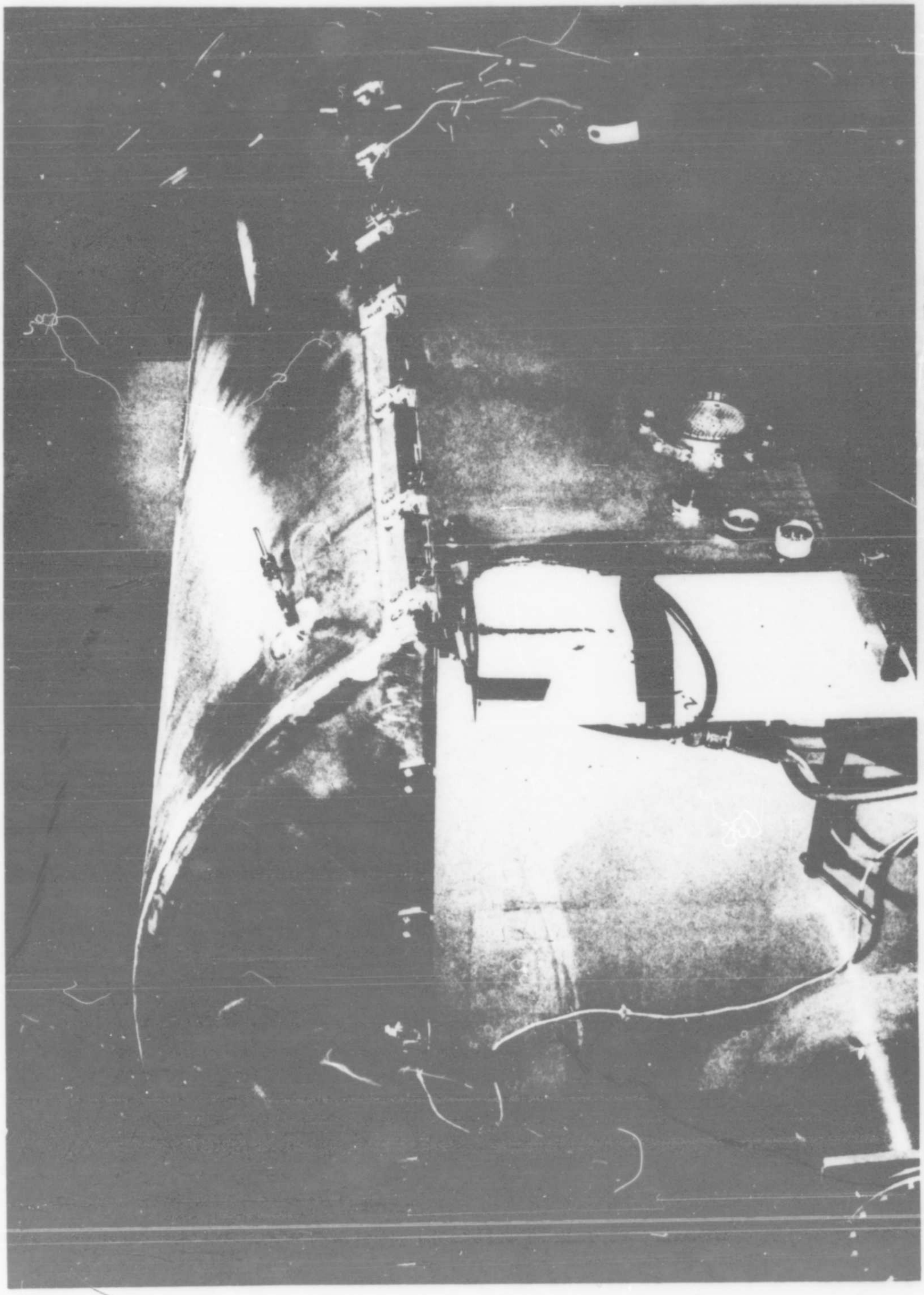

FIGURE 20 INSTRUMENTED EQUIPMENT COMPARTMENT AT 10 PSIG

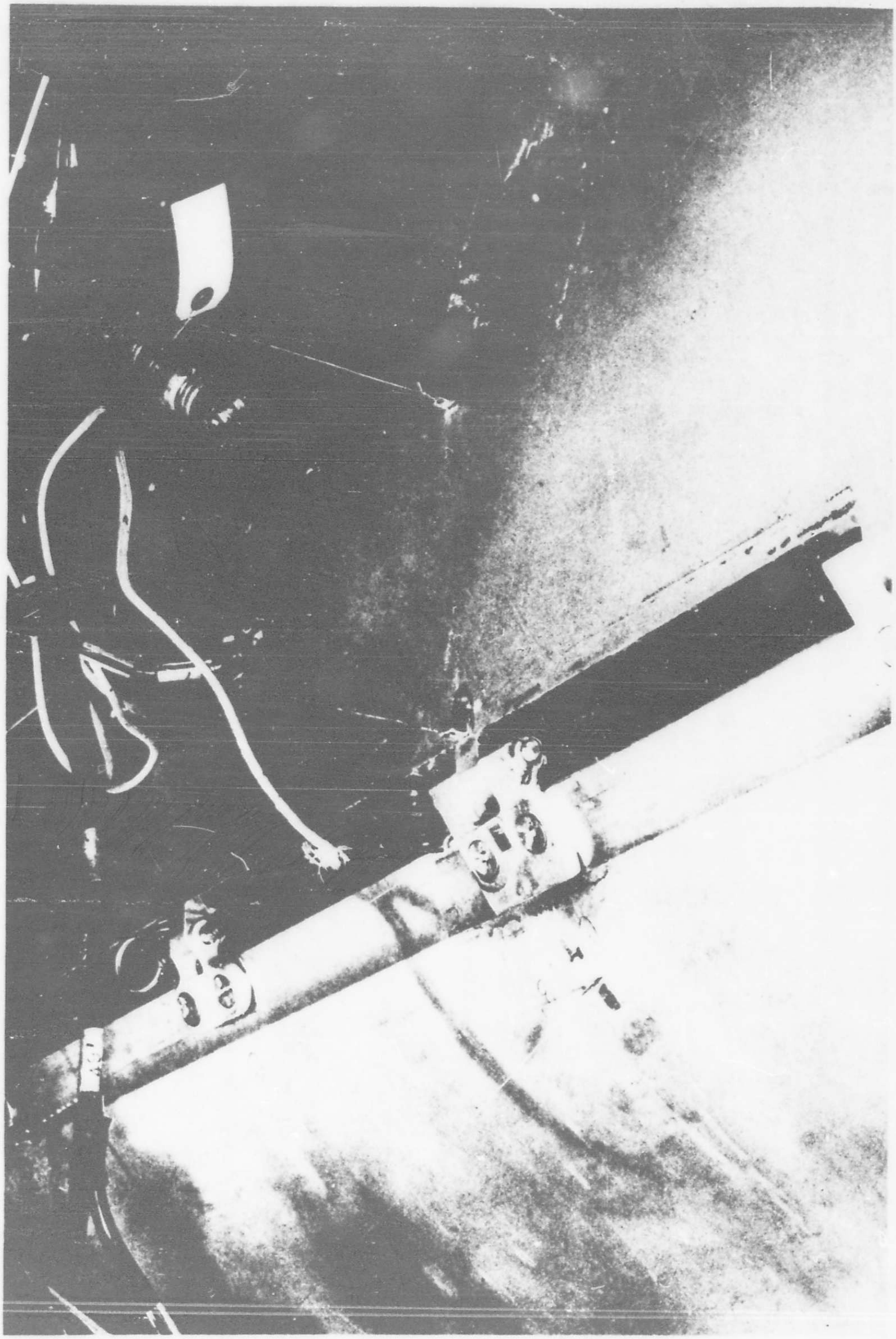

FIGURE 21 INSTRUMENT INSTALLATION

TABLE 4

PILOT'S COMPARTMENT LOAD AND DEFLECTION MEASUREMENTS

| NO. | LOCATION | PURPOSE | CALCULATED VALUE | MEASURED VALUE |
|---|---|---|---|---|
| 1 | Center of Window Post | Measure Deflection in Window Support Structure | .050 Inches Outboard | .029 Inches Outboard |
| 2 | Center of Window Post | Measure Deflection in Window Support Structure | .050 Inches Outboard | .025 Inches Outboard |
| 3 | Side Longeron | Measure Deflection in Deflection Critical Area | .056 Inches Outboard | .046 Inches Outboard |
| 4 | Aft Center of Longeron | Measure Deflection in Deflection Critical Area | .049 Inches Outboard | .027 Inches Outboard |
| 5 | Skin Adjacent to Weld | Measure Local Stress in Skin Panel Adjacent to Weld | 0 | 200 psi Tension |
| 6 | Tension Tie | Measure Load in Tension Tie to Determine its Usefulness | 4850 Pound Tension | 2026 Pound Tension |

TABLE 5

EQUIPMENT COMPARTMENT DEFLECTION MEASUREMENTS

| NO. | LOCATION | PURPOSE | CALCULATED VALUE (Inches) | MEASURED VALUE (Inches) |
|---|---|---|---|---|
| 1 | Left Hand Seal Plane | To Determine Increase in Seal Gap at Center Hinge | | .010 |
| 2 | Right Hand Seal Plane | To Determine Increase in Seal Gap at Center Hinge | | .009 |
| 3 | Forward Seal Plane | To Determine Increase in Seal Gap at Center of Bulkhead | | .073 |
| 4 | Aft Seal Plane | To Determine Increase in Seal Gap at Center of Bulkhead | | .058 |
| 5 | Left Hand Side of Access Door | To Determine Deflection in Access Door 3" Above Edge | | .023 Inbd |
| 6 | Left Hand Side of Access Door | To Determine Deflection in Access Door at Lower Edge | | .0415 Inbd |
| 7 | Left Hand Side of Lower Structure | To Determine Deflection of Structure at Outer Edge of Seal Plane | 0 | .046 Inbd |
| 8 | Left Hand Side of Lower Structure | To Determine Deflection of Structure 6" Below Seal Plane | .080 Otbd | .008 Otbd |
| 9 | Aft End of Access Door | To Determine Deflection in Access Door 3" Above Edge | | .046 Otbd |
| 10 | Aft End of Access Door | To Determine Deflection in Access Door at Lower Edge | | .044 Otbd |
| 11 | Aft End of Lower Structure | To Determine Deflection of Structure at Outer Edge of Seal Plane | 0 | .033 Otbd |
| 12 | Aft End of Lower Structure | To Determine Deflection of Structure 6" Below Seal Plane | .084 Otbd | .058 Otbd |
| 13 | Forward Bulkhead Frame Cap | To Determine Structural Deflection at Bulkhead Centerline | .053 Otbd | .051 Otbd |
| 14 | Forward Bulkhead Frame Cap | To Determine Structural Deflection at Bulkhead Centerline | .021 Otbd | .0053 Otbd |
| 15 | Floor Frame Cap | To Determine Structural Deflection at Floor Centerline | | .0162 Otbd |
| 16 | Floor Frame Cap | To Determine Structural Deflection - Floor Centerline | .076 Otbd | .056 Otbd |
| 17 | Left Hand Side Frame | To Determine Structural Deflection of Frame | .0078 Otbd | .0196 Otbd |
| 18 | Right Hand Side Frame | To Determine Structural Deflection of Frame | .0078 Otbd | .0173 Otbd |

## SECTION 7

## FABRICATION AND DESIGN PROBLEMS

During the assembly and testing of the compartments, the difficulties normally associated with the first production unit were encountered. These difficulties were resolved through the normal engineering/manufacturing liaison activities.

Only the standard design and fabrication procedures and techniques associated with similar high quality aircraft products were exercised. No special precautions or critical areas applicable to future programs were developed.

## REFERENCES

DRAWINGS

| | |
|---|---|
| 25-81601 | Structural Assembly - Pilot's Compartment |
| 25-81700 | Structure Assembly - Upper and Lower Equipment Compartment |
| 10-81136 | Inflatable Seal - Pilot's Hatch and Access Doors |
| 29-81152 | Seal-Molded, Front Windshield, Pilot's Compartment |
| 29-81153 | Seal-Molded, Side Windshield, Pilot's Compartment |
| 29-81154 | Seal-Molded, Side Window, Pilot's Compartment |

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